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ABSTRACT

This study was conducted to examine how the organization of preservice teachers' (N=23) knowledge about teaching changed during the last year of their undergraduate program which included a teaching methods course and student teaching. In order to explore cognitive organization three tools were combined: multidimensional scaling, concept mapping, and interviews. Subjects received instruction on how to draw concept maps and were asked to draw them four times--before the senior year, at the end of the fall semester, in the middle of student teaching, and at the end of student teaching. Following each phase, the previous map was returned and subjects were to decide if they would organize their knowledge differently. Prior to an interview they were asked to draw a new map, modify their old one, or redraw the old map as it was. Drawings were coded and scored and the sample concepts of "flexibility" and "planning" were selected for further analysis through multidimensional scaling and student interviews. Data analysis revealed that during student teaching the preservice teachers' pedagogical knowledge underwent radical reconstruction, involving a reorganization of prior knowledge, theories, and beliefs. Figures depicting concept maps and students' multidimensional scaling are included. (Contains 22 references.) (LL)

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Changes in the Structure of Pedagogical Knowledge of Middle School Preservice Teachers

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Changes in the Structure of Pedagogical Knowledge of Middle School Preservice Teachers

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The purpose of this study is to examine how the organization of preservice teachers' knowledge about teaching changes during the last year of their undergraduate program, including their student teaching. The student teaching experience is a major component of teacher preparation programs, but little is known about the impact of specific experiences on student teachers' pedagogical knowledge. Questions identified by Shulman (1986) are applied here to preservice teachers: "What are the sources of teacher knowledge? What does a teacher know, and when did he or she come to know it? How is new knowledge acquired, old knowledge retrieved, and both combined to form a new knowledge base?" (p. 8)

Changes in the organization of knowledge have been described as either weak restructuring, such as accretion, or as radical reconstruction. Accretion, according to Rumelhart and Norman (1976), involves the daily accumulation of knowledge. Radical reconstruction, on the other hand, involves changes in core concepts and a change in the organization of the cognitive structure. The shift from novice to expert levels of performance in areas like chess and physics are examples of radical reconstruction (Vosniadou & Brewer, 1987).

The midpoint of student teaching has been described as a time of crisis or paralysis of action (Corcoran, 1981; Veenman, 1984). In a previous study, we found that student teachers' interactions with their pupils decreased midway through the student teaching (Jones & Vesilind, in press). Results of this previous study suggested that the student teachers were attempting to find predictable patterns and sequences of behaviors that they could control. The changing interaction patterns of those student teachers may have signaled a time of radical reconstruction of knowledge.

In order to explore more fully preservice teachers' cognitive organization, we combined three tools in the present study — multidimensional scaling, concept mapping, and interviews. Multidimensional scaling has been used to examine the semantic dimensions underlying a domain of concepts and provides information about the organization of concepts in memory (Cooke, 1990). The results of

multidimensional scaling represent cognitive "distances" among concepts. For example, the more frequently two concepts are associated in a sorting task, the shorter the distance between them in the scaling. Distance may be thought of as a measure of the association a person makes between concepts. Multidimensional scaling solutions have been shown to be psychologically meaningful (Cooke, 1990) for analogy completion (Rips, Shoben, & Smith, 1973), similarity judgment time (Hutchinson & Lockheed, 1977), categorical judgment time (Shoben, 1976), and judgments in an inductive reasoning task (Rips, 1975).

Concept mapping has also been used to examine how individuals organize their knowledge (Novak & Gowin, 1984; Markham, Mintzes, & Jones, 1994). Cary (1986) suggests that "by comparing successive concept maps produced as the student gains mastery of the domain, the researcher can see how knowledge is restructured in the course of acquisition" (p. 1126). Unlike multidimensional scaling, which measures cognitive "distance," concept mapping reveals hierarchies and links among concepts.

In the present study concept maps were used to signal changes in complexity and integration of the preservice teachers' concepts. Multidimensional scaling was used to identify which concepts and associations were changing.

In addition, structured interviews were conducted to gather student teachers' explanations of their maps, concept sorting and descriptions of sources of change. The interviews were used to triangulate the results of the scoring of the concept maps and the multidimensional scaling of the sorting tasks.

Research Questions

1. How do student teachers' concepts of effective teaching change through time?
2. Do student teachers perceive changes in the organization of their concepts?
3. Do changes in the organization of concepts represent accretion or radical reconstruction of knowledge?

Methodology

Subjects

The subjects in this study were 23 seniors enrolled in the middle grades teacher education program at a large southeastern university. During the fall semester the students participated in a middle grades methods course of 6 credit hours. This course included instruction in teaching methods for two content areas (language arts, mathematics, science, or social studies), middle school philosophy, and methods for teaching reading and writing across the content areas. In addition, students were required to observe classes at their student teaching placement site for at least 2 hours each week from August until January. From January through May students completed 16 weeks of student teaching, returning to the university for a weekly seminar. The seminar provided opportunities for students to reflect on their student teaching, to share experiences with the group, and to receive support for solving problems encountered during student teaching. The seminar also included presentations on topics including gender and multicultural issues in teaching, censorship in schools, and job search strategies.

Procedure

In August of the senior year students received instruction on how to draw concept maps. They drew practice maps about sample topics such as sports and were then given an hour to draw a concept map about "effective teaching." The subjects drew concept maps four times: in August before the senior year, at the end of the fall semester (early January), at the middle of student teaching (early March), and at the end of student teaching (May). At the last three sessions the previous map they had drawn was returned to the students, and they were asked to study the map and to decide if they would organize their knowledge differently. Students were instructed to draw a new map, modify their old map, or redraw the old map as it was. Within an hour after they had drawn their maps, the students were interviewed. Five interviewers used a structured interview script. The interviewers asked subjects to discuss the maps and concepts related to

teaching. If students indicated changes in their maps they were asked to describe what factors influenced them to make changes. Interviews were audio recorded and later transcribed.

The cooperating teachers and university supervisors also drew concept maps at the beginning and end of the year. These data are being described in a subsequent report. After the preservice teachers, cooperating teachers, and supervisors had drawn their first maps, a frequency count was made of the concepts that appeared most frequently on the maps. The 20 most frequently used concepts were identified. These were expressed in words and short phrases, such as "planning," "class management," and "parents." These 20 concepts were written on index cards and were given as a card sorting task after the second, third, and fourth concept map interviews. Subjects were instructed to sort the cards into piles according to how they thought the cards "go together." They were told that they could have as many or as few piles of cards as they wanted. The subjects were left alone until they had completed the task. Then they were individually interviewed and asked to describe their rationale for sorting each card.

Analysis

The concept maps were coded and scored, using a procedure described by Novak and Gowin (1984) and Markham, Mintzes, and Jones (1994). In this process, subscores are calculated for each map. The subscore categories are: examples, relationships, hierarchies, and crosslinks.

Examples are specific events or objects that are judged as valid instances of a concept. To illustrate, in Figure 1 "visual" is scored as an example of "learning styles."

Relationships are defined as the connecting lines and linking words between two concepts, between a concept and an example, or between two examples. Relationships used in Figure 1 include "requires," "produces," and "utilizes."

Hierarchies are connections among concepts and examples, from general to specific. A hierarchy found in Figure 1 connects "effective teaching," "flexibility," "teaching strategies," and "discussion."

Crosslinks are connections between a segment of one hierarchy and a

segment from another hierarchy. A crosslink in Figure 1 is the connection drawn between "teaching strategies" and "presentation."

The concept map subscores across the four time periods were analyzed with multivariate analysis of variance. To determine whether or not the preservice teachers radically reorganized their maps or simply added and deleted concepts at lower levels on the hierarchies, we examined the superordinate concepts on the maps. Superordinate concepts were defined as those highest in a hierarchy and connected directly to the title "effective teaching."

The results of the sorting task were analyzed with multidimensional scaling (Kruskal & Wish, 1978; Young & Rheingans, 1991). A matrix was created that represented how frequently preservice teachers placed any one of the 20 concepts from the card sorting task with another concept. Multidimensional scaling algorithms then took pairwise proximity estimates for the set of concepts and generated multidimensional models of these concepts.

Two researchers independently coded the interviews for categories of sources of change. Interrater reliability was calculated as .88. For those items in disagreement, the two researchers discussed the items and ultimately reached consensus. Each of the subjects' explanations about changes in their maps was coded into a category that represented a source of change. The categories that emerged from this analysis were: the cooperating teacher, student teaching experiences (parents, other teachers, students and extracurricular activities), classes at the university, future jobs, peers, family, media, map design (changes related to subjects' perceptions of their maps), professional conferences attended, and books or other readings.

The interviews were analyzed for each student, as well as for the whole sample within and across each time period, as well as across different interview questions. As the transcripts were read and reread by two researchers, categories of responses were identified through a process described by Erickson (1986). As categories were created, responses were compared and contrasted across students and type of question (Miles & Huberman, 1984). Data from the interviews were triangulated with the

concept maps and the multidimensional scalings.

Results

Concept Maps

In this section we describe the results of the concept mapping. Figures 1-4 show examples of concept maps drawn by Shelley, a mathematics student teacher. Although Shelley's maps are unique, they are representative of the number of concepts and crosslinks typical of the other student teachers' concept maps. A sharp increase in the number of crosslinks and concepts is seen in map 3, which was drawn during the middle of student teaching when Shelley was teaching a full load of classes.

The concept map scores for the 23 participating student teachers are shown in Table 1. The multivariate analysis revealed a significant difference in concept map scores across the three time periods (Wilk's Lambda = 0.63, $F = 2.23$, $p < .003$). Specifically there was a significant time effect between map 1 and map 3 ($F = 4.05$, $p < .003$), and between map 1 and map 4 ($F = 3.6$, $p < .006$).

Table 1

Student Teachers' Mean Concept Map Scores.

	Mean (Standard Error)			
Category	Map 1 (August)	Map 2 (January)	Map 3 (March)	Map 4 (May)
Examples	11.4 (2.4)	13.6 (3.1)	7.9 (1.6)	8.7 (1.9)
Relationships	56.1 (4.0)	61.6 (4.3)	60.9 (4.6)	58.0 (4.9)
Hierarchies	27.3 (1.3)	25.8 (1.3)	26.3 (1.3)	26.5 (1.8)
Crosslinks	45.6 (9.5)	53.7 (16.6)	77.8 (15.4)	72.2 (16.1)

Note. N= 23.

The number of examples decreased during the middle and end of student teaching. Several students indicated during the map 3 and 4 interviews that they focused more on the overall organization of their

maps and omitted specific examples of some concepts. For example, Katie said, "I think that I have narrowed it down. I have a lot of things out there, but I've realized what's the most important." In the first map, students used more examples but used fewer crosslinks between hierarchies. This suggests that at the beginning of the senior year the students held detailed knowledge of selected concept hierarchies, but that they lacked integration among hierarchies and concepts.

The initial analysis of the superordinate concept means showed that the total number of superordinate concepts increased for each sequential concept map, suggesting accretion of knowledge (Table 2). However, when the mean number of superordinate concepts that were added or deleted was determined, the greatest number of changes appeared in the third map. These changes in the superordinate or organizing concepts, along with the results of the multivariate analysis of variance for concept map scores across time, provide evidence that radical reconstruction of knowledge is taking place when the student teacher is most actively teaching.

Table 2

Mean Changes in Superordinate Concepts

Mean	Map 1 (August)	Map 2 (January)	Map 3 (March)	Map 4 (May)
Superordinate Concepts	3.7	4.7	5.0	5.2
Superordinate Concepts Lost		-.7	-1.9	-.6
Superordinate Concepts Gained		+1.7	+2.2	+.8
Total Number of Changes		2.4	4.1	1.4

Note. Concepts lost or gained reflect changes from the previous map.
Note. N=23.

When students were interviewed about their second maps, 56% of the reasons they cited for the changes from map 1 were related to experiences

that they had at their field placement (Table 3). Their university classes were listed as the second most frequent (23%) influence on the changes in the second map.

Table 3

Students' Explanations for Concept Map Changes

Category	Frequency of Response		
	Map 2 (January)	Map 3 (March)	Map 4 (May)
Cooperating Teacher	8	5	1
Student Teaching Experiences	1	26	13
1. Experiences With Students		6	14
2. Experiences With Other Teachers	1	4	11
3. Parents		7	7
4. Extracurricular Activities	1	1	
Other		2	
Classes at the University	16	2	3
Observations at the Student Teaching Site	27	3	4
Future	1		4
Metacognition	3	4	7
Peers	3		1
Family	1		1
Media	3		
Map Design	3		3
Conferences Attended		8	1
Readings		1	1
Total	68	69	71

The interviews about map 3 took place when the students were in the middle of their student teaching. The university classes were no longer cited as a primary reason for changes made in the third concept map. Students attributed the changes in their concept maps primarily to their student teaching experiences (78%). Attendance at the state middle school conference was also given by 12% of the students as a factor that influenced the organization of their third map. For map 4, the changes were attributed predominantly to the experiences the student teachers had during their student teaching, although other factors such as getting a future teaching job and peers were also cited.

Multidimensional Scaling Results

The multidimensional scalings (MDS) for the card sorting tasks also provided evidence that students changed their knowledge organization while student teaching (Figures 5-7). An examination of the spatial relationships among the 20 concepts showed that students organized their knowledge differently for each sorting task. When analyzed with the student interviews and concept maps, the differences in the three multidimensional scalings revealed a pattern. The changes in preservice teachers' knowledge organization coincided with the changes in teaching experience and responsibilities that took place during student teaching.

The first concept sorting task took place in January when the student teachers were preparing to enter student teaching. During this period they anticipated establishing class management systems, new lesson plans, as well as developing relationships with their students.

The second sorting task took place during the middle of student teaching when the students were teaching a full load of classes and had primary responsibility for all planning, instruction and evaluation. For most student teachers this period was a time of trying to cope with the realities and complexities of teaching. Their personal and professional goals conflicted at times with the unpredictability of student behavior, changing school schedules, and their own novice understanding of the teaching-learning process.

The third sorting task took place at the end of student teaching. The

interviews revealed that during this period students discussed concepts and educational processes in a more global, reflective way. Their sorting rationales included descriptions of more complex relationships among the 20 variables. They were no longer concerned with the unpredictability of their situation, but were making more holistic connections among the variables involved in teaching.

Among the concepts that were changing on the multidimensional scaling, two of these concepts-- "flexibility" and "planning" -- were also discussed at length during the interviews. These concepts were selected for further analysis. In the sections that follow, we trace the movements of these sample concepts on the sequential multidimensional scalings and through the student interviews to describe the nature of the changes in knowledge organization experienced by this group of preservice teachers.

Flexibility

On the first multidimensional scaling the concept "flexibility" was closely associated with the concepts "preparation," "organization," and "class management" (Figure 5). The data from the student interviews indicated that students viewed flexibility in the context of being prepared for class, as well as being flexible in implementing rules. Mark, one of the student teachers, shared his view of flexibility as a concept related to organization and instruction:

> *"I think organization comes from proper preparation. With proper preparation you can be flexible. This preparation leads you to have flexible instruction... Organization also aids you in flexibility of scheduling and having flexible instruction."* (Mark, Interview 1)

Another student teacher, Sam, stated:

> *"If you have good class management, that allows for flexibility and organization. I consider flexibility and organization as part of planning."* (Sam, Interview I)

Anna shared this view of flexibility as being prepared:

> *"I felt like these (concept cards) were things that a teacher would have before even making out lesson plans. I mean the type of teacher that is flexible and understanding and going through life always prepared for things or used to making themselves prepared and organized. These things make a good and efficient classroom, an open classroom. These are characteristics of a teacher, a good teacher."* (Anna, Interview I)

In the second multidimensional scaling, the concept "flexibility" moved away from preparation and organization and was more closely associated with the cluster of concepts that the student teachers described as those possessed by the teacher ("teaching experience," "instruction," "subject knowledge," and "teaching methods") (Figure 6). In the interviews about the second sorting task, students described flexibility as a characteristic that the teacher needs in order to cope with the unpredictable situations that arise while teaching. According to the students, this type of flexibility involves lesson plans and teaching strategies.

> *"You also need to have a lot of flexibility because you never know what is going to happen in a given class period or a given class day."* (Karen, Interview II)

> *"I feel like the teacher has to be flexible, flexible in all aspects. You have to be able to address your lesson plans to different students, you have to be able to adjust the overhead projector when it goes out and your whole lesson was planned around the overhead. You have to be flexible and you have to have the flexibility for your students."* (Eliza, Interview II)

"Flexibility" was reorganized again on the last multidimensional scaling and was associated with a series of concepts including "rules," "planning,"

"organization," "preparation," and "class management" (Figure 7).

The context the student teachers used to talk about flexibility during the last interview was different from that of the first or second multidimensional scalings. "Flexibility" was discussed in the last interview as a complex concept related to differentiating instruction for individual student needs, being flexible with parents, other teachers and administrators, as well as being flexible to seize the "teachable moment." The students' descriptions of flexibility suggest they are no longer concerned with surviving the unpredictable, but that instead they are seeking to understand the educational system and the fundamental purposes of teaching. Leslie, in her third interview, described flexibility as seeing beyond her needs and goals as a teacher and including students and their needs in her view:

> *"I've thought I wouldn't be very flexible. I've seen teachers who are so rigid that it would drive me crazy to see how important that is. And I've seen teachers who are so flexible that they don't get anything done. I mean seeing different teachers teach made me sort of find my niche and see where it fits into the whole picture. You hear all the time 'you have to be flexible with the kids' and I never really thought that it was that big of a deal. You know, oh sure, I can do some different kinds of things, but it goes beyond using different teaching styles and presentation. You have to be flexible in your morals, your own values, your own way you want things to be, because it doesn't always go that way."* (Leslie, Interview III)

Another student teacher described flexibility as being student-centered:

> *"I think as the semester progressed I began to see how much education should be student-centered. And that the teacher is there for the students. You can have this nice six-step lesson plan, but a teacher has to be flexible and willing to bend a little bit and do things around a child and a child's needs."* (Katie, Interview III)

Flexibility took on a dimension of spontaneity for Katherine:

> *"I did a lot over here (on my concept map) with what I learned about flexibility. I feel like I've really improved on as far as my flexibility, such as bringing spontaneous enthusiasm and the teachable moment. It is something you don't always read about, but it is definitely exciting in the classroom if you can get a hold of that."* (Katherine, Interview III)

In summary, flexibility was initially associated with preparation for class. Then, when student teachers were teaching a full load, the concept of flexibility was related to the unpredictability of teaching. Toward the end of student teaching flexibility was related to differentiating for students' individual needs and adapting instruction flexibly to take advantage of the teachable moment.

Planning

The concept "planning" is associated in the first multidimensional scaling with the concepts "preparation," "flexibility" and "materials" (Figure 5). Student teachers used planning as a concept related narrowly to preparing lesson plans and obtaining materials for future teaching. But by the second multidimensional scaling, planning also became associated with organization and continued to be located near flexibility (Figure 6).

The impact of full-time teaching experience changed the notion that planning is an unalterable event, but instead planning became a concept associated with the unpredictability of classroom events. Stuart, one of the student teachers, described planning and flexibility as closely related concepts:

> *"Well, it is hard to think about things being planned and at the same time flexible and then sequential. If it is flexible, how can it be sequential and flexible? I don't know if they are mutually exclusive but they are not synonymous. Well, I mean if*

something screws up in the middle of your plan, or if some kind of response that you expect in your planning doesn't happen, then you have to be able to change your plan on the spot. Or, what happens with me really regularly is I'll plan two days ahead of time and the rest of it will take the rest of the week. I don't think you always know how far you are going to get, or how it is going to go as you are trying to get there." (Stuart, Interview II)

For the third multidimensional scaling, student teachers associated "planning" as a concept closely related to "flexibility," "class management" and "rules" (Figure 7). Their interviews indicated that they were seeing relationships between being well prepared (lesson plans and materials), maintaining good class management (rules) and being flexible in meeting their students' needs. It was as if they began student teaching holding all the pieces of the puzzle, but only through their successive experiences were they able to organize these pieces into meaningful patterns.

"I think the concepts preparation, planning and materials go together. In order to teach, the first thing you have to have is all these. But you also have to have class management of some description or your students will be bouncing off the walls. You can't teach them anything. First you have to have consistent rules that the students know about. You have to be organized and prepared and have your planning done so you know what you are going to do and have your materials ready. Because if all those things are not done and ready when you walk into a classroom, you can't run around and try to find the materials you need or pull something out of a hat. The kids will know you are pulling it out of your hat. If you don't have things prepared, while you are trying to get something prepared, they (the students) are off doing their little thing bouncing off the wall." (Ellen, Interview III)

For Keesa, another student teacher, planning and modifying instruction for students were concepts that were closely connected:

"I think week by week I began to connect with the students more and that helped me be able to enjoy my teaching more and be more effective because I was more relaxed and wasn't so concerned with getting through with what I had planned from one day to the next. And I saw how important being flexible is. I've also seen how every student can learn. Just because a child is very slow and may not do as well as a smarter child, that student can still learn. They just learn at their own pace. I've seen that gradually week by week... So many times in the classroom with the perfect lesson plan you may not get through everything that you want to in one day and you have to realize that you may have to pick up the next day and carry over what you did the day before, or there may be one day where your lesson plan might take just fifteen minutes and you have to be able to jump in there and plan something just like that. You have to see where you are going and have to stop it and go slower or speed up or you have to tend to one little group's needs. Oh, you just have to be flexible." (Keesa, Interview III)

In summary, the concept "planning" was organized in the early stages of student teaching as a concept related to planning lessons and obtaining materials. In the middle of student teaching, planning was associated with the unpredictability of classroom events. Finally, student teachers related planning to the relationships between lesson planning, maintaining class management and meeting students' needs.

When examined individually, the concept maps, multidimensional scalings, and student interviews revealed changes in the organization of student teachers' concepts, especially the concepts "flexibility" and "planning." The multidimensional scalings showed that the associations among the 20 concepts related to teaching changed throughout the year. The concept maps showed which concepts student teachers considered important, as well as the hierarchies and links in which these concepts were organized. The student interviews revealed the sources of change, the context of change, and the direction of change, as well as the nature of

links between concepts. By triangulating these three sources of data, we were able to reconstruct the student teachers' cognitive journey.

Discussion

Our analysis of concept maps, sorting, and interviews suggests that during student teaching the preservice teachers' pedagogical knowledge underwent radical reconstruction. Further, these changes in the organization of pedagogical knowledge were not only changes resulting from what is often called "putting theory into practice." The radical reconstruction involved a reorganization of the preservice teachers' prior knowledge, theories, and beliefs. It was as if they were "putting practice into theory."

The strongest quantitative evidence of this radical reconstruction of prior knowledge was the change in superordinate concepts on the maps during the midpoint of student teaching. Superordinate concepts are those concepts at the highest level in the hierarchies on the maps. Changes at those levels of the maps provided new possibilities for crosslinks among hierarchies. As Table 2 displays, the change was not in total numbers of superordinate concepts, but in revision of those concepts. In other words, the preservice teachers were not primarily adding superordinate concepts to their maps during the beginning and middle of student teaching, but they were replacing previous hierarchies and subordinating previous superordinate concepts under new ones.

Figures 1 – 4 illustrate this radical reconstruction. We see how Concept Map 3 marks a revision of the superordinate concepts in Maps 1 and 2. "Preparedness" has been deleted, while "systems," "positive relationships," and "performance" appear as superordinate concepts for the first time. Both the "systems" and "performance" hierarchies are crosslinked with other hierarchies, so that these revisions enhance the cohesion and integration of the whole map. Such changes at the highest levels of the map and in the cohesion of the map we interpret as radical reconstruction, a change more profound than accretion of new examples of concepts.

The interviews gathered at the midpoint and conclusion of student teaching also point to radical reconstruction of knowledge, in that the student teachers discovered integrations of concepts. Many of these new

integrations were about the teachers' growing ability to include information about students into their teaching decisions. In the earlier interviews the preservice teachers talked about planning and flexibility in terms of their own preparation of lesson plans and instructional materials. The later interviews, however, revealed student teachers' insights about connections between their own planning and their understanding of students' individual needs, and insights about the connectedness of classroom management, planning, and student outcomes.

The later interviews also revealed student teachers' metacognitive awareness of their own changing concepts. The student teachers talked about concepts learned in university courses in terms of specific students and events of their teaching. They spoke of improved control of classroom events, which they no longer viewed only in terms of their own behavior but in terms of how events in the classroom were interrelated. They talked about their changed priorities, especially about incorporating students' needs into planning and into the pace of instruction. Concepts from university courses, like flexibility and lesson plans, were now discussed in the context of stories about interactions with students, parents, and other teachers.

In contrast, during the fall semester <u>before</u> student teaching, the changes evident in pedagogical knowledge were changes more akin to accretion, as evidenced by elaboration of existing superordinate concepts and hierarchies. This elaboration took the forms of increases in examples of concepts and increases in levels of hierarchies on the concept maps, changes attributed by students to their university courses. Although crosslinks and superordinate concepts changed during this fall semester, those changes, which we associate with radical reconstruction, were more pronounced in March, the midpoint of student teaching.

Although we at first interpreted changes in the superordinate concepts as a deficit, a lack of stability in the pedagogical knowledge of these student teachers, we now find it more useful to view the changes as a readiness for growth.

What might appear as unstable knowledge organization actually may have allowed the student teachers to change in response to new experience

and to contextualize their knowledge. This interpretation is aligned with McClelland and Rumelhart's (1986) revised schema theory, in which schemata are defined as "more flexible, more sensitive to context, more adaptable" than earlier applications of schema theory allowed (p. 1).

At the same time we noted from our routine supervision of the student teaching that the reorganization of knowledge at the highest levels of conceptual hierarchies was disorienting for many student teachers, especially as the conceptual reorganization coincided with the student teachers' assumption of a full load of classroom responsibilities. The middle of student teaching is a time in which student teachers have been described as in "reality shock" (Veenman, 1984) or as "paralyzed" (Corcoran, 1981). Our data suggest that such crises may result not simply from additional teaching loads, but also from the student teachers' uncertainties about the organization of their pedagogical knowledge.

As the effects of student teaching are observed in the data in this study, we can question whether these changes describe student teachers' movement toward pedagogical knowledge more like that used by expert teachers. Leinhardt (1988) suggests that the schemata possessed by expert teachers contribute to the ability to work with speed and fluidity. Carter, et al. (1987) associate certain qualities of pedagogical schemata with teaching expertise:

> Expert teachers, like other experts, appear to bring rich schemata to the interpretation of phenomena, and these schemata appear to provide them with a framework for meaningfully interpreting information. Experts' schemata allow them to weight information so that its saliency and utility are determined quite quickly. In teaching, such skill in processing information is necessary because of the complex, dynamic, information-rich world of the classroom. It is likely that a necessary though not sufficient condition for the development of these skills is experience. (p. 156)

Richness and fluidity of pedagogical schemata, as described by Carter et al. (1987), may be indicated in our data by crosslinks in the concept maps.

Thus interpreted, rich schemata are relatively well integrated, so that an effective teacher can draw quickly on many diverse aspects of her pedagogical knowledge in her classroom decisions and interactions. The links and relationships within rich schemata may allow the expert teacher to work with fluidity, using students' cues to modify continually the lessons and management systems in the classroom. Thus differences between novice and expert teachers may be expressed as differences in the richness of connections among the schemata, rather than as differences in the stability of schemata. The organization of superordinate concepts affects the possibilities for these connections and so also may distinguish novices from experts.

If such integration of pedagogical knowledge is a goal, and if radical reconstruction accompanies the contextualizing of pedagogical knowledge, how then can we nurture this cognitive reorganization in preservice teachers?

University courses can provide models for integrating concepts across areas of pedagogical knowledge. Professors can make explicit the dynamic relationships among concepts in child development, social foundations, motivation, learning theory, class management, and methods of teaching content areas. For example, journal writing, a strategy commonly recommended in methods courses, can be related to learning theory, class management, motivation, social values, and child development. Courses in which students learn to defend their unit plans and lesson plans by using concepts from all areas of pedagogical knowledge could provide preservice teachers with a model for integrating what sometimes are compartments of pedagogical knowledge presented in separate university courses. In other words, we may need to illuminate explicitly the possible structures of pedagogical knowledge and not simply present fragments of these structures.

Self-reports about the sources for changes in the maps and sorting revealed diverse influences on student teachers' pedagogical knowledge. The influence of university courses and observations at the field site diminishes as the influence of student teachers' interactions with pupils, parents, and other teachers increases. The influence of the cooperating

teacher was most often cited at the beginning of student teaching and is less often cited at the middle and end of student teaching. Two other sources of change were cited by at least 7 student teachers: personal reflection and attendance at a professional conference. Readings, family members, and extracurricular activities were relatively uninfluential in changing the organization of pedagogical knowledge during the semester of student teaching.

These results suggest that the practicum experience can be enriched by supplementing classroom teaching with other forms of professional experiences in which the student teachers can interact with more experienced teachers.

The nurturing of radical reconstruction in preservice teachers' pedagogical knowledge is perhaps a more subtle task. Paralysis, crisis, or milder cases of self–doubt can be diagnosed as opportunities for growth. For example, student teachers' questioning of the relevance of their university coursework to student teaching may be a positive sign that the student teachers sense not only a need to contextualize their knowledge, but an awareness that such putting of theory into practice means a reorganization of the theory, too.

By enhancing preservice teachers' metacognitive skills and by providing them with strategies and opportunities for reflection, the student teachers themselves can learn to work through periods of cognitive reorganization. Journal writing, as well as open–ended seminars at the university, can help student teachers to reflect deliberately on their changing pedagogical knowledge.

Interestingly, the subjects in this study reported that the drawing of concept maps helped them to diagnose areas of confusion in their pedagogical knowledge. Three questions used during the structured interviews seemed to the interviewers especially helpful to the student teachers' own reflection. These were: "What has changed since your last map?" "Why do you think that changed?" "What area of your map are you least sure about right now?" This kind of directed reflection helps student teachers in at least three ways: it provides a model for taking charge of their own professional growth; it conveys the message that

pedagogical knowledge is a dynamic resource that will grow well beyond the university coursework; and it provides a model for integrating coursework and experience, for contextualizing pedagogical knowledge.

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Figure 1. Concept Map 1

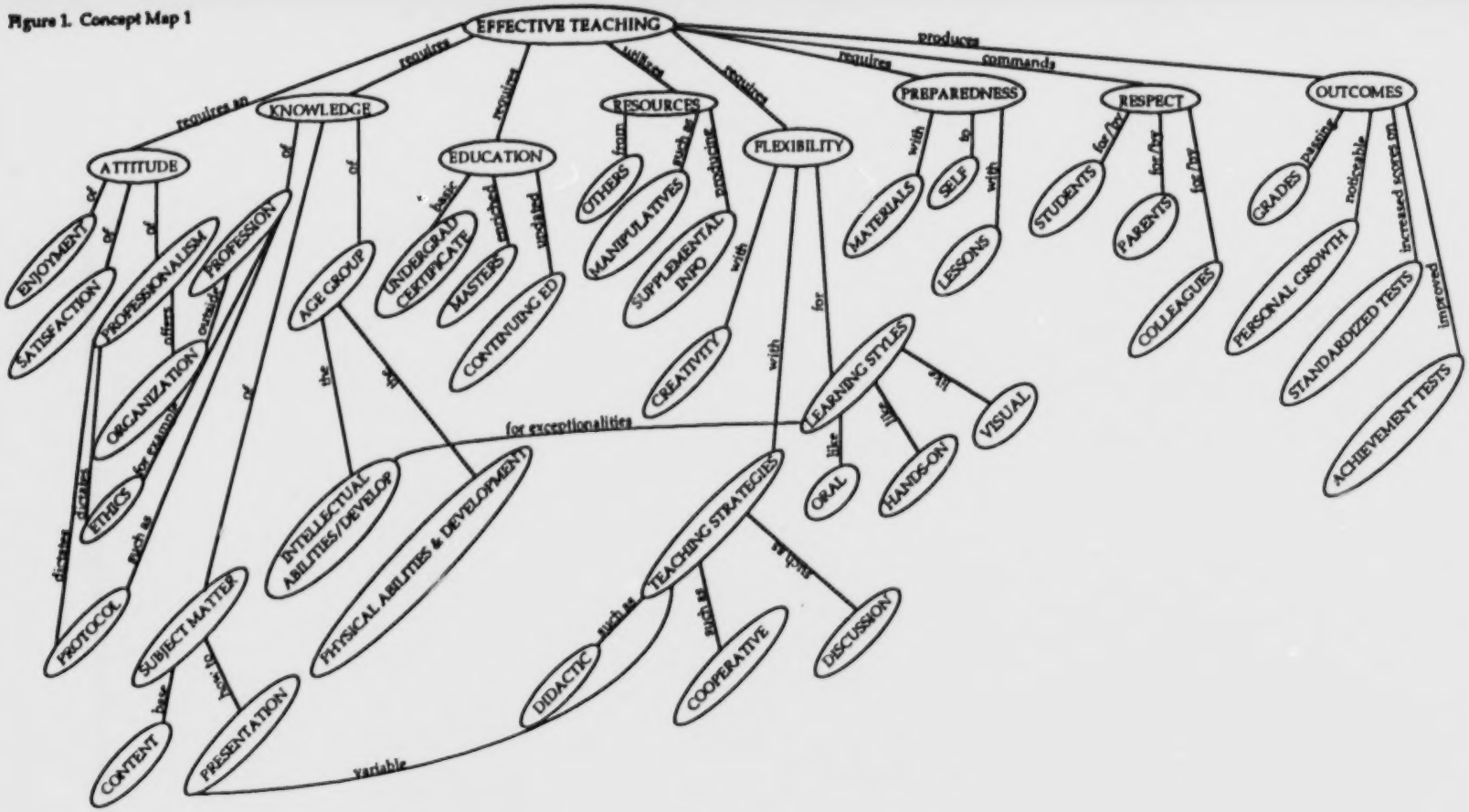

Figure 2. Concept Map 2

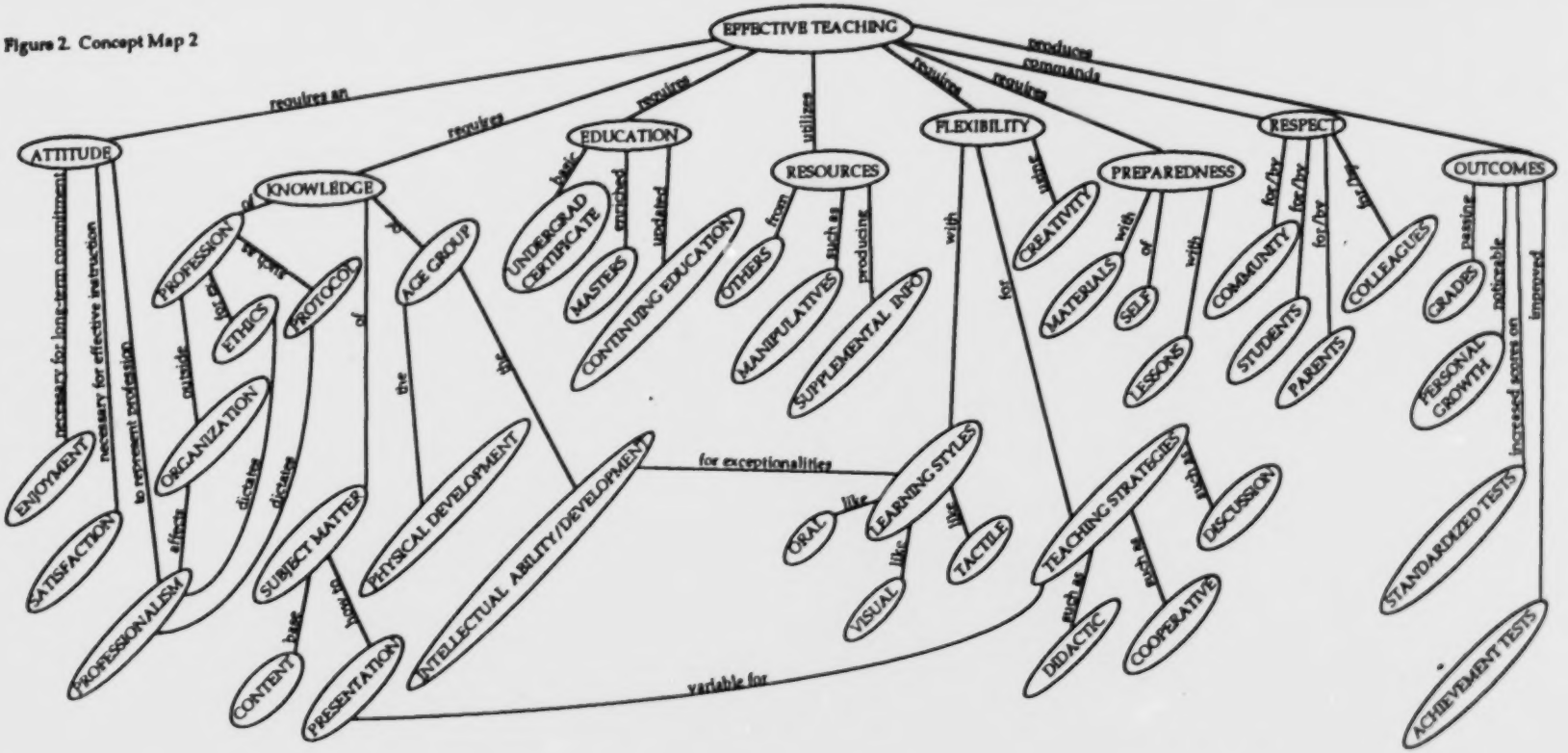

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Figure 3. Concept Map 3

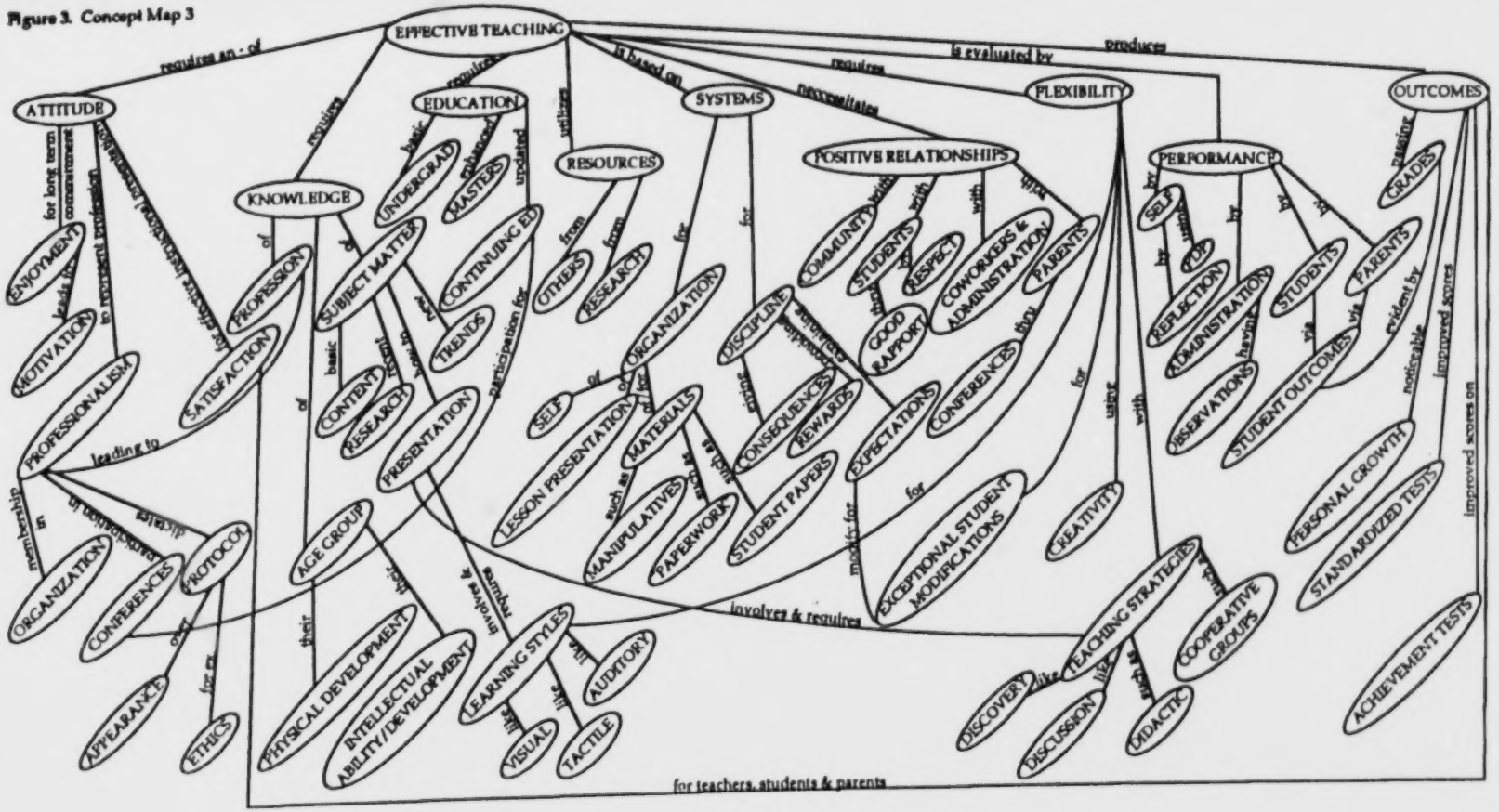

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Figure 4. Concept Map 4

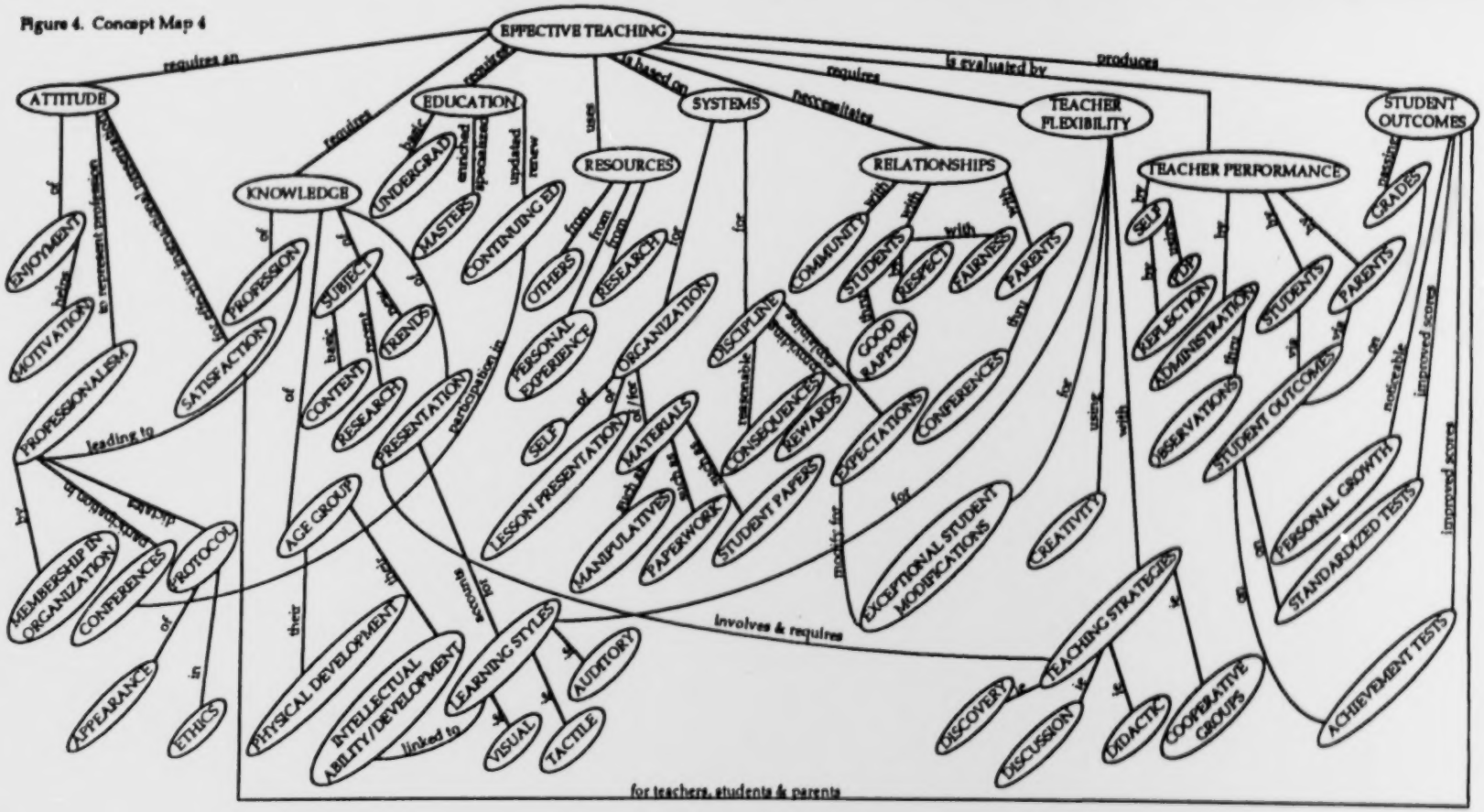

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Figure 5. Students Multidimensional Scaling 1

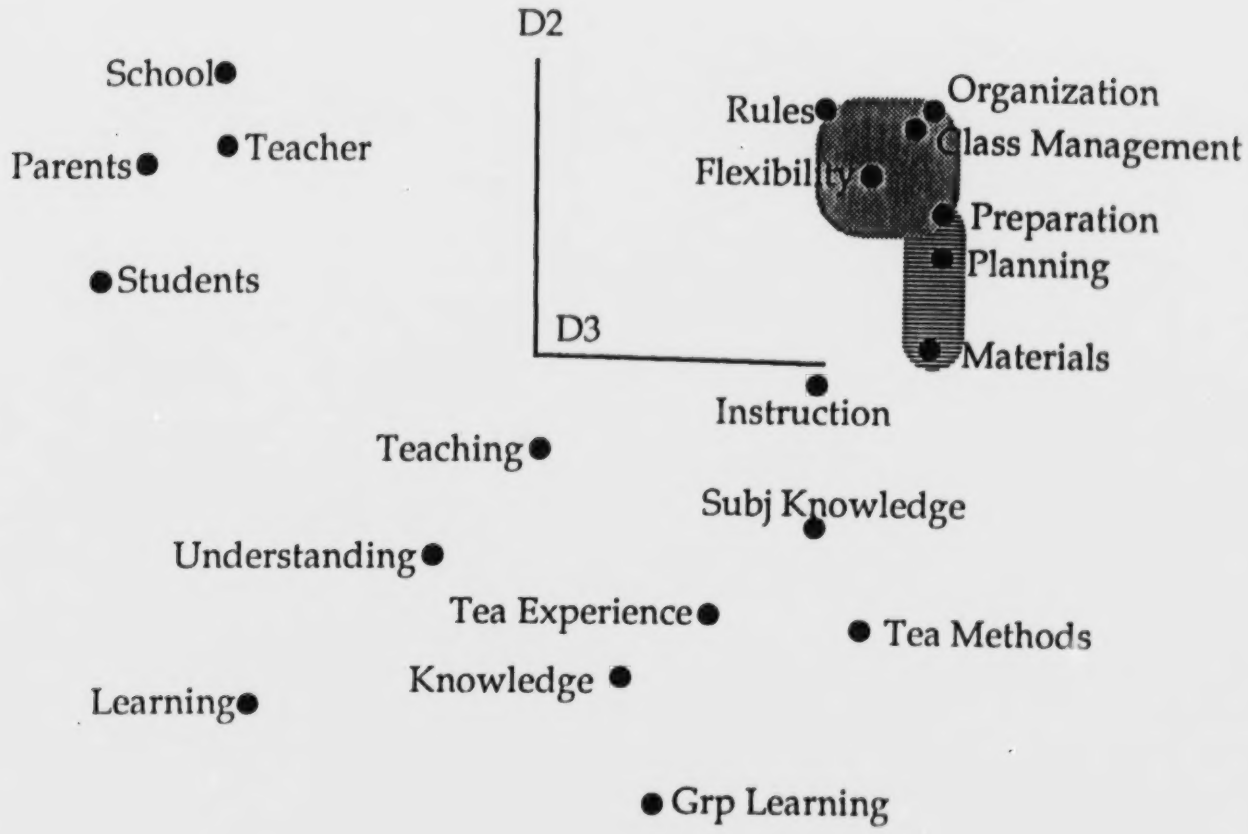

Figure 6. Students' Multidimensional Scaling 2

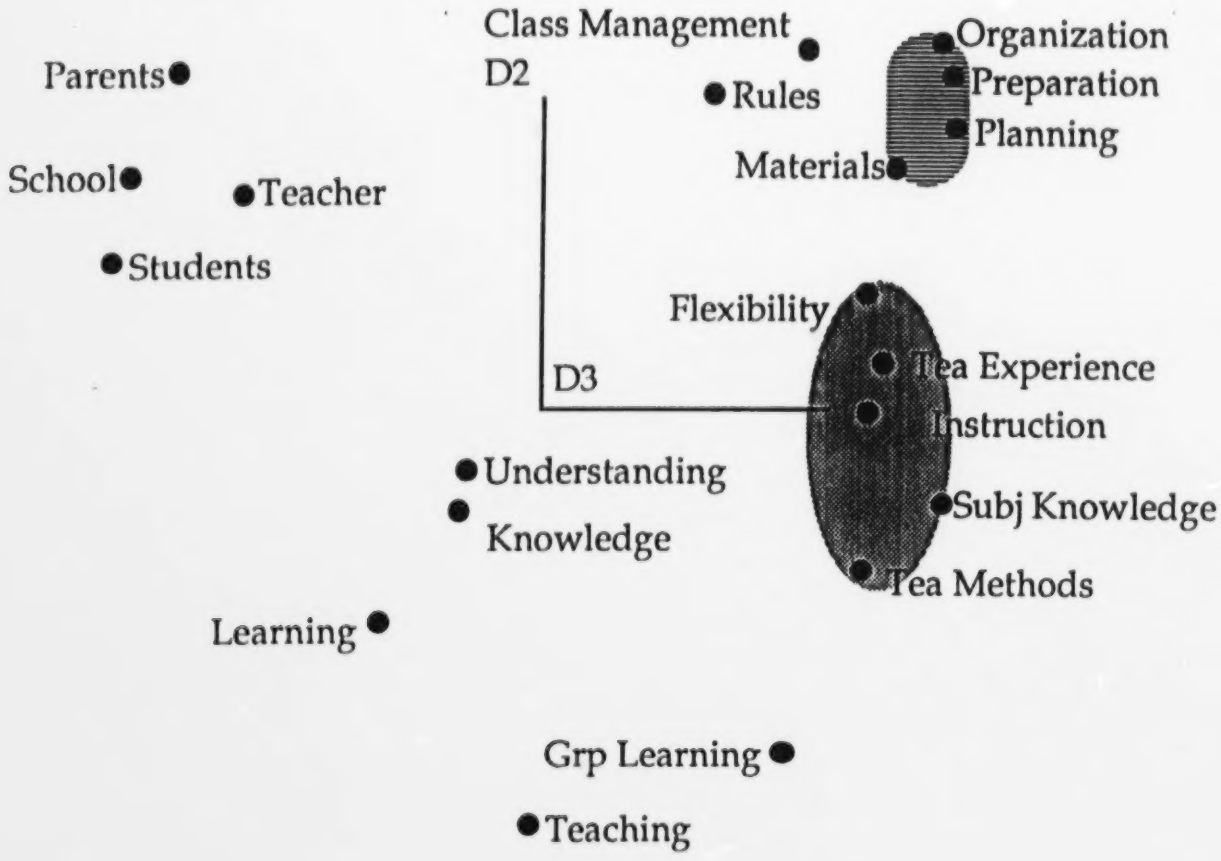

Figure 7. Students' Multidimensional Scaling 3